

.The US West Coast Component of the Coastal Ocean Modeling Testbed (COMT)

Principal Investigators:

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Co-Investigators:

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Andrew Moore, UCSC

Bruce Cornuelle, UCSD

Fei Chai, U. Maine

Federal Partners:

Frank Aikman, Edward Myers (NOAA NOS CSDL)

Eric Bayler (NOAA JCSDA)

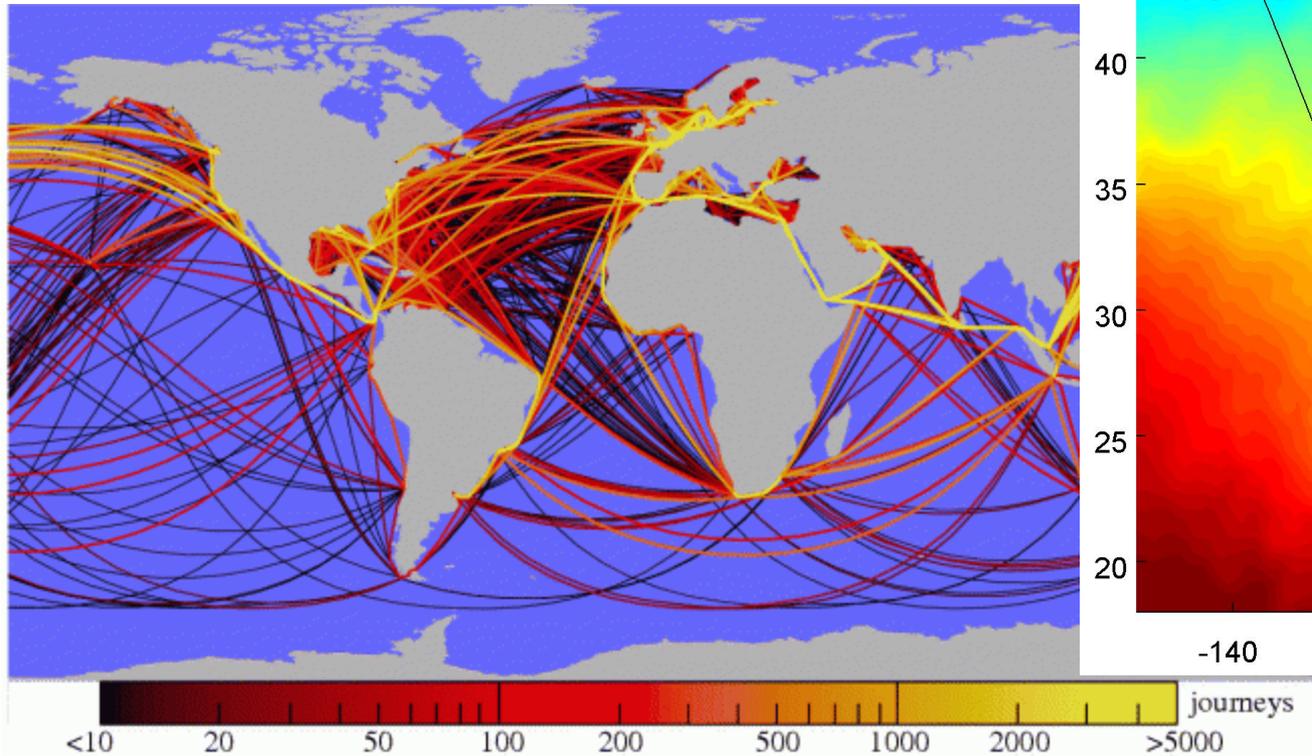
Avichal Mehra (NOAA NWS NCEP)

Igor Shulman (Naval Research Laboratory)

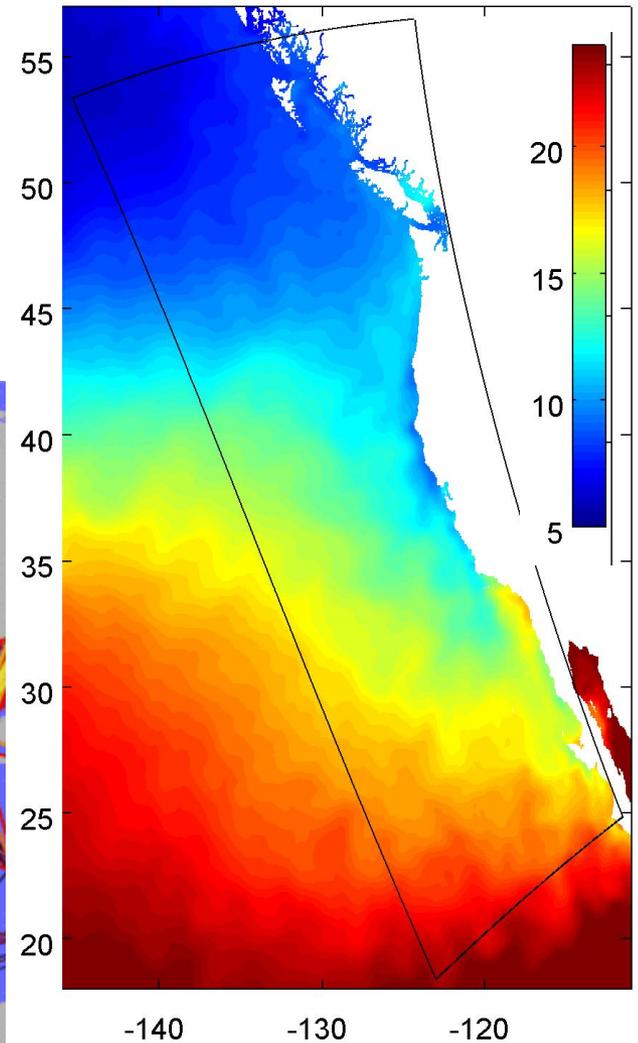
COMT: - R. Luettich, B. Baltes, et al.

US West Coast:

- fisheries
- navigation
- coastal populations (Seattle, Portland, San Francisco, Los Angeles, San Diego)



OSTIA 01-May-2009 ... 01-Jun-2009



<http://www.wired.com/2010/01/global-shipping-map/>



Credit : Eric Mortenson, Doug Beghtel /The Oregonian, www.naturalbuy.com, USCG, <http://i.livescience.com/>, Grantham et al. (2002)

Coastal Ocean Circulation Models

- Predict currents, temperature, salinity

Coupled physical-biological models:

- biological properties (nutrients, phytoplankton, zooplankton)

Data assimilation

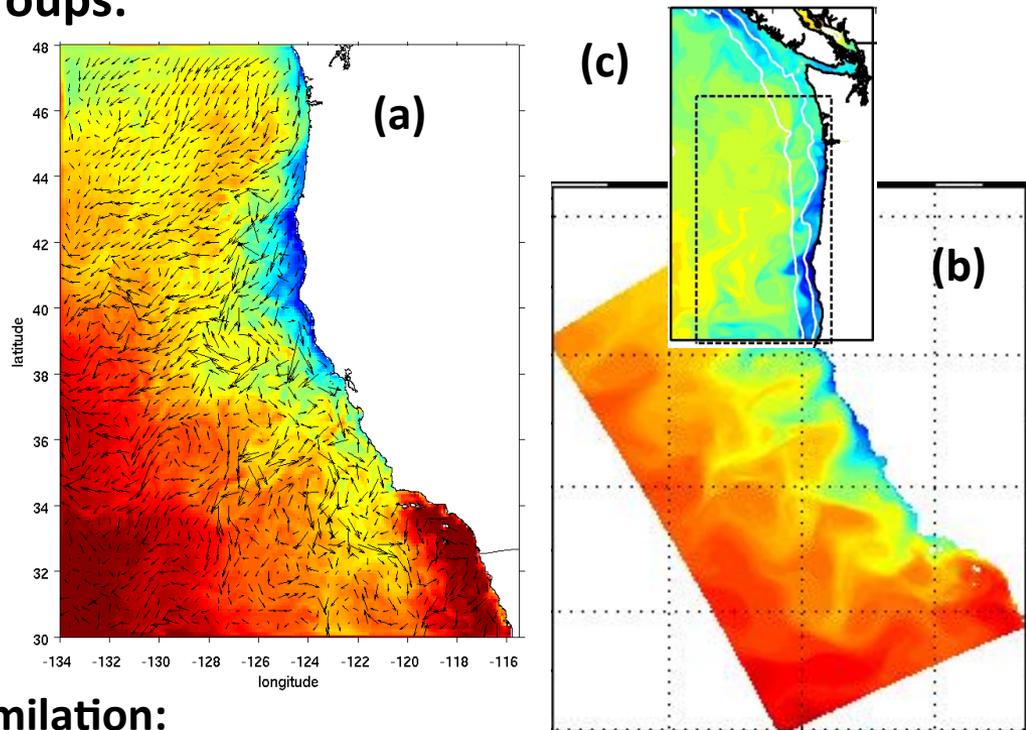
- Optimally combine models and observations to obtain the best estimate of the ocean (initial conditions for accurate forecasts)

Support:

- Fisheries management
- Search & Rescue
- Environmental hazard response
- Navigation
- Recreation

WC COMT participating groups:

IOOS RAs:
CenCOOS
SCCOOS
NANOOS



Circulation models, data assimilation:

(a) Edwards, Moore: WC Regional model, 10-km res. + 4DVAR

(b) Chao: CA 3-km res. + 3DVAR

| new: EnKF (w/ B. Cornuelle)

(c) Kurapov: OR+WA 2-km res. + 4DVAR

Coupled bio-chemical modeling:

NEMURO (11 components) w/ WC regional model

CoSINE (13 components) w/ CA model– F. Chai

NPZDO (6 components) w/ WA model (N. Banas, UW)

Intercomparisons:

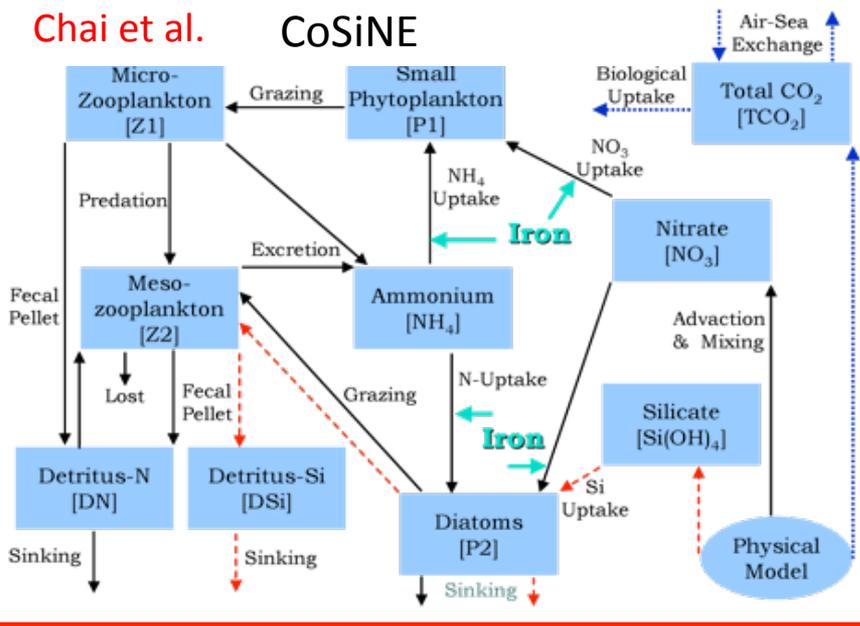
- Bio-chemical models (coupled with the same ocean circulation model) (Edwards, Banas, Chai)
- Data assimilation: 4DVAR vs. hybrid ensemble-variational method (Kurapov, Cornuelle)
- Data assimilation: 3DVAR vs. EnKF (Chao, Cornuelle)
- Data assimilation: new metrics for observational impact assessment based on 4DVAR (Moore)

Transition to operations:

WC COMT  NOAA West Coast Ocean Forecast System (WCOFS)
(PI: Kurapov, OSU – NOAA NOS, NESDIS, JCSDA)

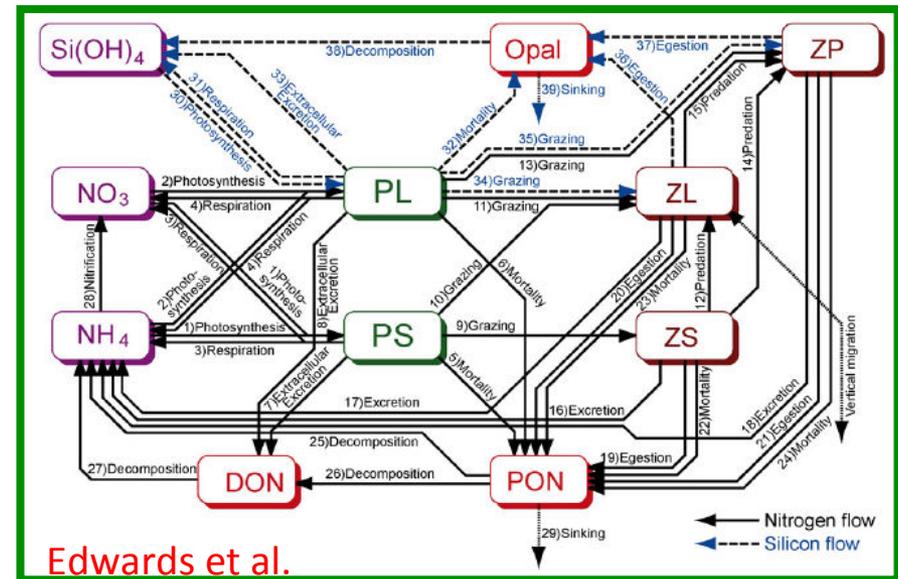
Chai et al.

CoSiNE



3 Biogeochemical Models

NEMURO



Edwards et al.

A biogeochemical model for the US Pacific Northwest coast

NPZD (Cascadia)

(NS Banas et al. JGR, 2009,
KA Davis et al. in prep,
S Siedlecki et al. in prep)

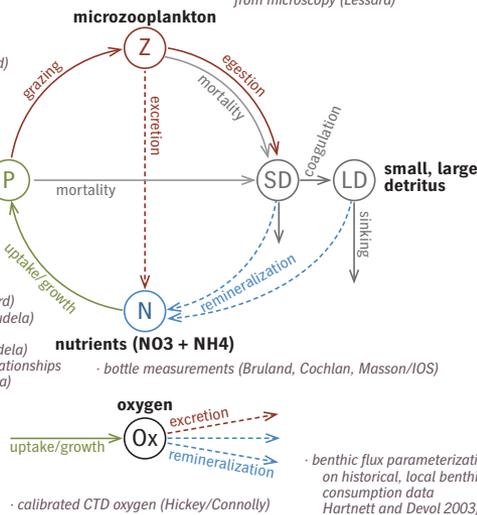
· biomass and species composition
from microscopy (Lessard)

· dilution experiments (Lessard)

Banas et al.

· satellite and bottle chl (Kudela)
· POC:PON:chl stoichiometry (Kudela)
· biomass and species composition
from microscopy (Lessard)

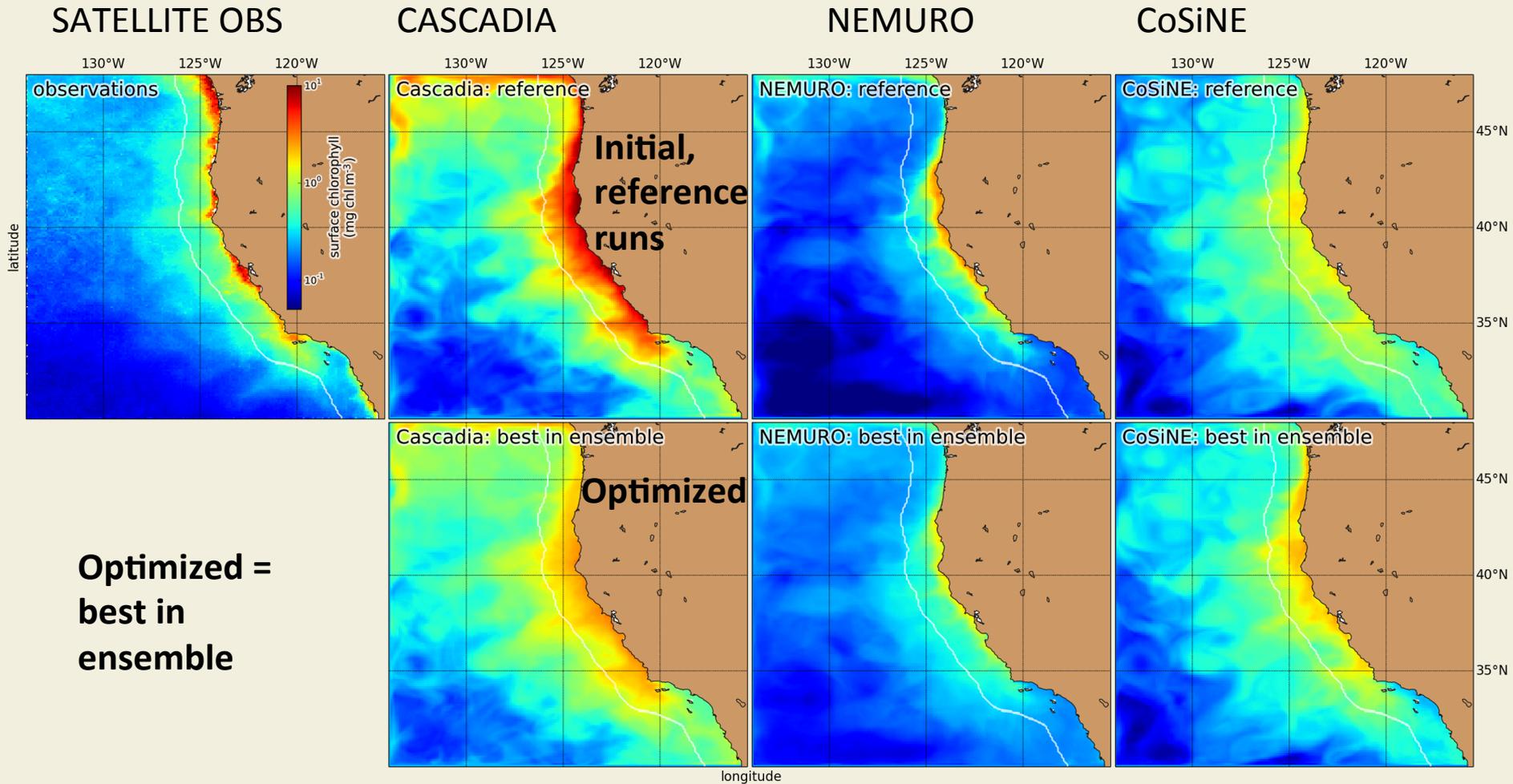
· dilution experiments (Lessard)
· ¹⁴C primary productivity (Kudela)
· deckboard incubations and
growth kinetics expts (Kudela)
· attenuation-chl-salinity relationships
from CTDs (Hickey, Kudela)



· calibrated CTD oxygen (Hickey/Connolly)

· benthic flux parameterization based
on historical, local benthic oxygen
consumption data
Hartnett and Devol 2003)

surface chlorophyll in reference vs best in ensemble



2000, annual mean

model cost function $J(\theta)$

A metric to optimize model bio parameters

The cost function $J(\theta)$ summarizes model performance in one number.

$$J(\theta) = \underbrace{\frac{1}{3} \frac{J_{nut}(\theta)}{J_{nut}(\theta_{ref})}}_{\text{NO}_3\text{-based}} + \underbrace{\frac{1}{3} \frac{J_{coastal}(\theta)}{J_{coastal}(\theta_{ref})} + \frac{1}{3} \frac{J_{offshore}(\theta)}{J_{offshore}(\theta_{ref})}}_{\text{Chl-based}}$$

contributions:

$$J_{nut}(\theta) = \frac{1}{4} \sum_{t \in \{\text{JFM, AMJ, JAS, OND}\}} \frac{1}{2} \left(\frac{1}{n_t} \left| \sum_{i=1}^{n_t} \bar{m}_{i,t}^{\text{NO}_3}(\theta) - \sum_{i=1}^{n_t} \bar{o}_{i,t}^{\text{NO}_3} \right| + \sqrt{\frac{1}{n_t} \sum_{i=1}^{n_t} \left(\bar{m}_{i,t}^{\text{NO}_3}(\theta) - \bar{o}_{i,t}^{\text{NO}_3} \right)^2} \right)$$

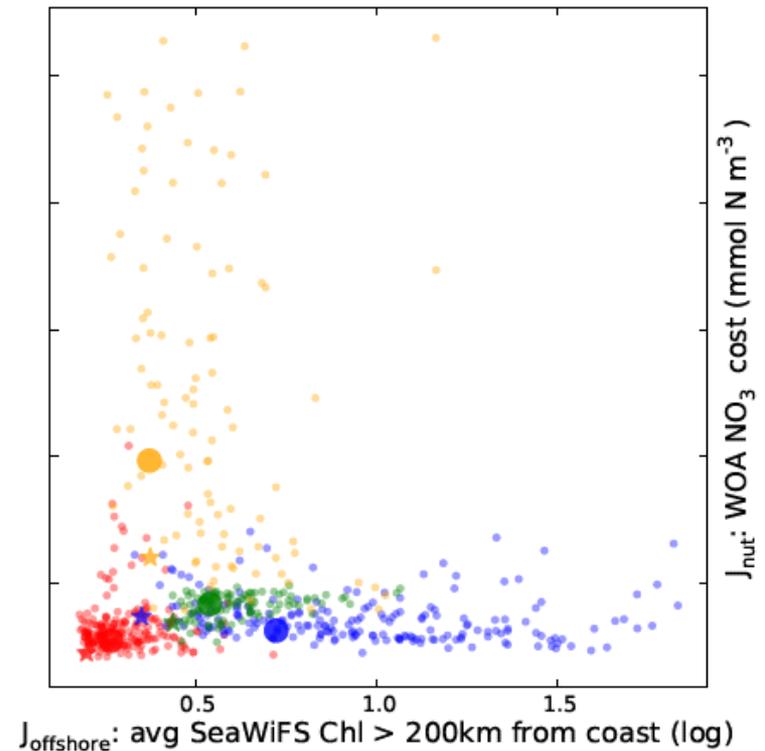
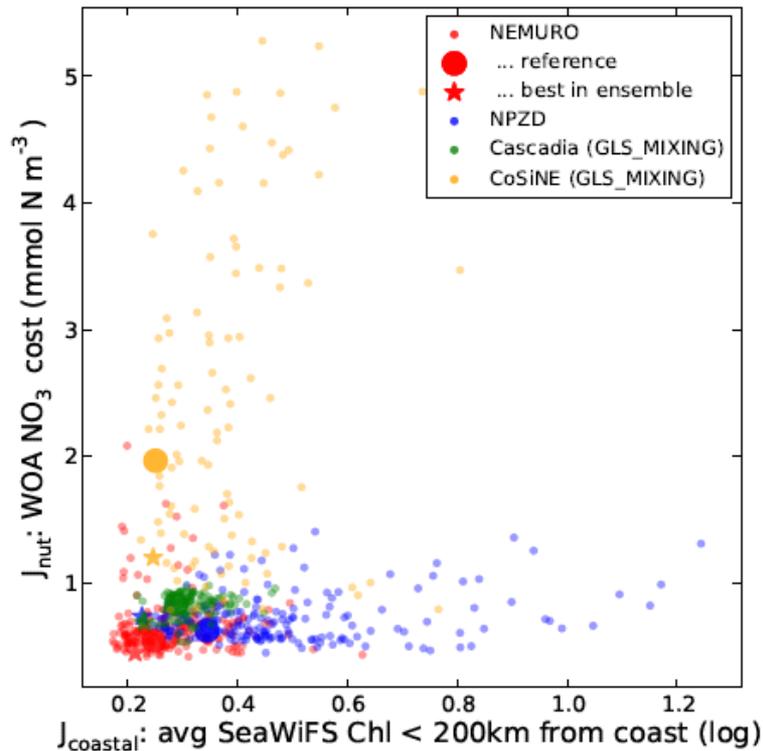
$$J_{coastal}(\theta) = \sqrt{\frac{1}{\#G_{coastal}} \sum_{x \in G_{coastal}} \frac{1}{12} \sum_{t=1}^{12} \log \left(\bar{m}_{x,t}^{\text{chl}}(\theta) / \bar{o}_{x,t}^{\text{chl}} \right)^2}$$

$$J_{offshore}(\theta) = \sqrt{\frac{1}{\#G_{offshore}} \sum_{x \in G_{offshore}} \frac{1}{12} \sum_{t=1}^{12} \log \left(\bar{m}_{x,t}^{\text{chl}}(\theta) / \bar{o}_{x,t}^{\text{chl}} \right)^2}$$

(Edwards et al.)

Sensitivity of different models to variation in biological parameters

NPZD:	4 variables	9 biological parameters varied
NEMURO:	11 variables	44 (+4) biological parameters varied
Cascadia:	5 variables	13 biological parameters varied
CoSiNE:	10 variables	33 (+1) biological parameters varied



Testing new metrics for data assimilation impact assessment, based on the adjoint algorithm (Moore)

Example: Observation Impacts on 37N Transport

$$\mathbf{x}_a = \mathbf{x}_b + \mathbf{K}(y - H(\mathbf{x}_b))$$

posterior=prior + gain×innovation

Consider a scalar function:

$$I(\mathbf{x})$$

(transport at 37N,
coast to 127W, 0-500m in this case)

Change in I due to 4D-Var:

$$\Delta I = I(\mathbf{x}_a) - I(\mathbf{x}_b)$$

$$\Delta I = I(\mathbf{x}_b + \mathbf{K}\mathbf{d}) - I(\mathbf{x}_b)$$

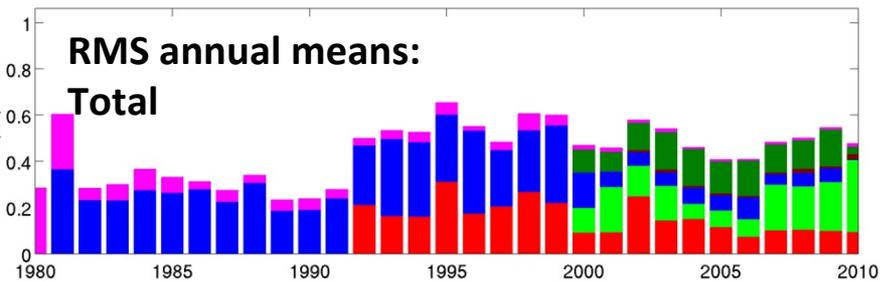
$$\approx \mathbf{d}^T \mathbf{K}^T (\partial I / \partial \mathbf{x})|_{\mathbf{x}_b}$$

$$= (\mathbf{y} - H(\mathbf{x}_b))^T \mathbf{K}^T (\partial I / \partial \mathbf{x})|_{\mathbf{x}_b}$$

Change in I can be uniquely attributed to each obs y_i , the transpose (adjoint) of the gain matrix \mathbf{K}^T

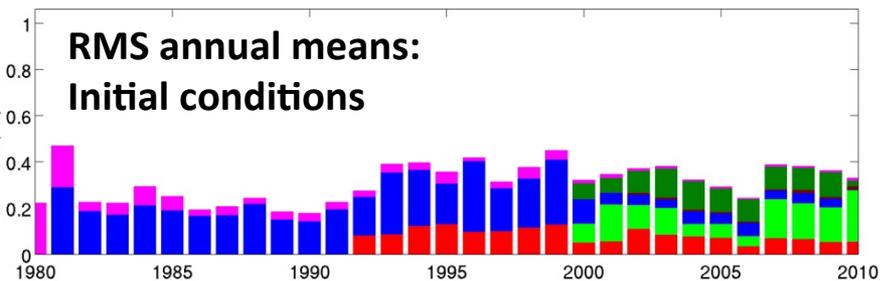
RMS Total Increment

**RMS annual means:
Total**



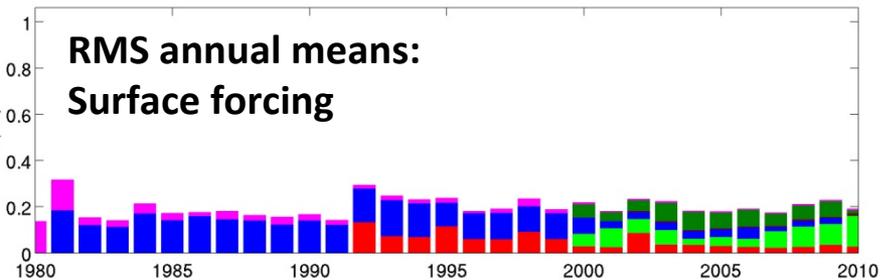
RMS Initial Conditions

**RMS annual means:
Initial conditions**



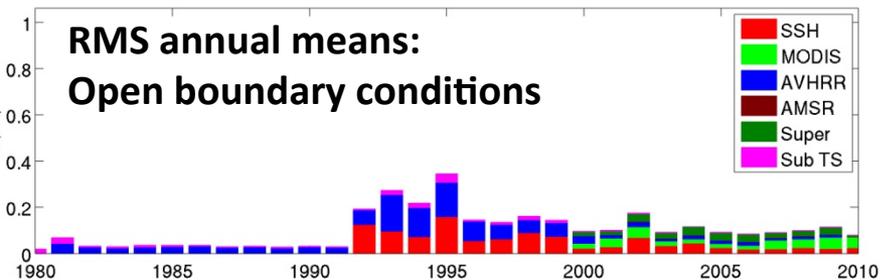
RMS Surface Forcing

**RMS annual means:
Surface forcing**



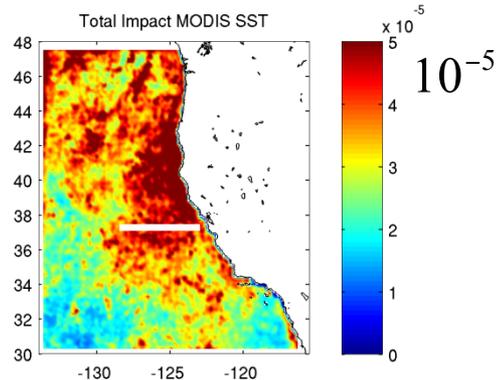
RMS Open Boundary Conditions

**RMS annual means:
Open boundary conditions**

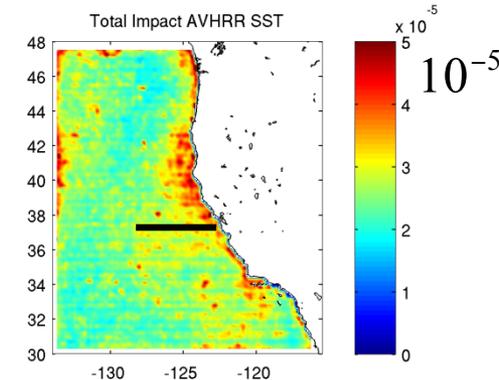


- SSH
- MODIS
- AVHRR
- AMSR
- Super
- Sub TS

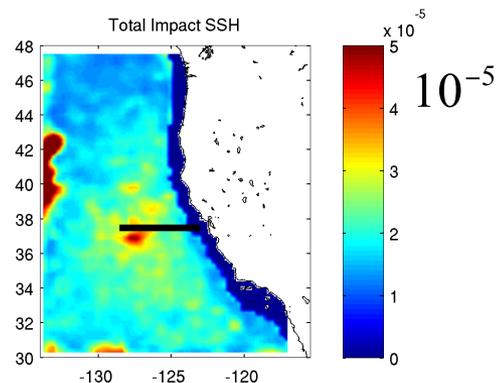
Total Impact MODIS SST



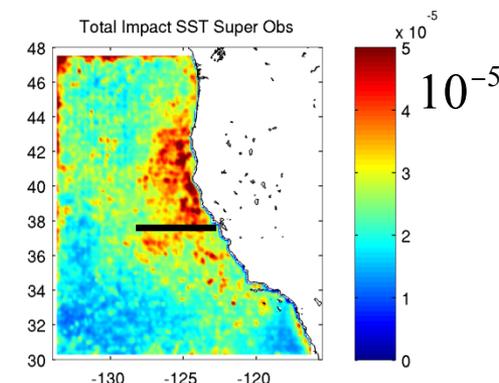
Total Impact AVHRR SST



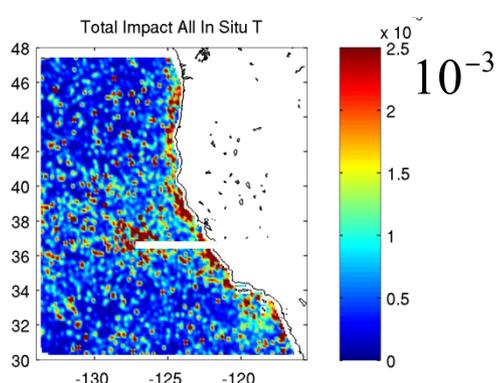
Total Impact SSH



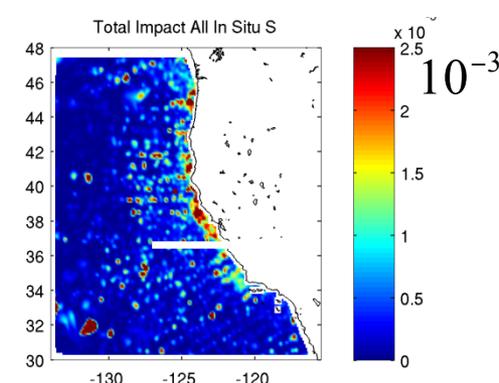
Total Impact SST Super Obs



Total Impact All In Situ T



Total Impact All In Situ S



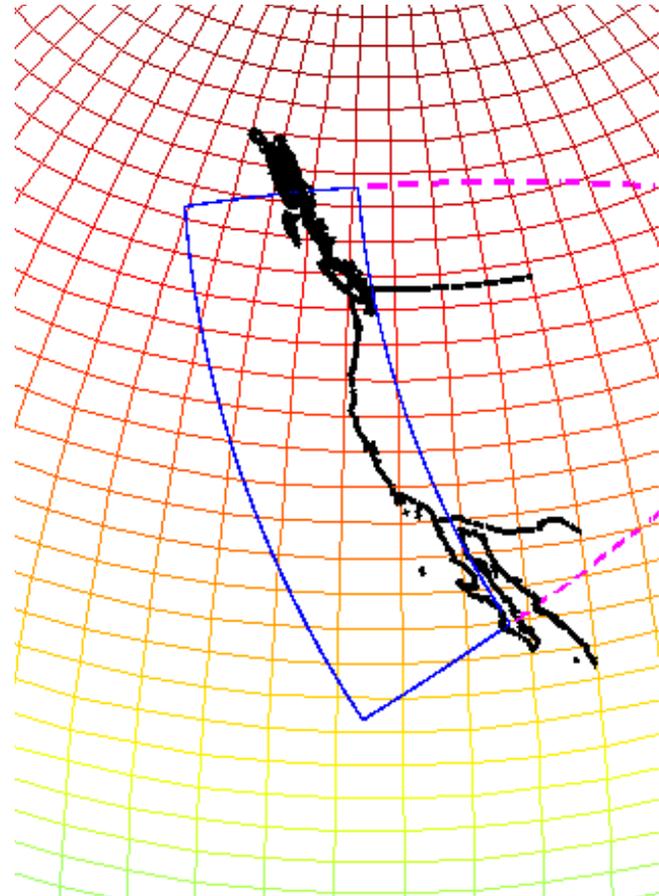
COMT => Transition to operations

WCOFS:

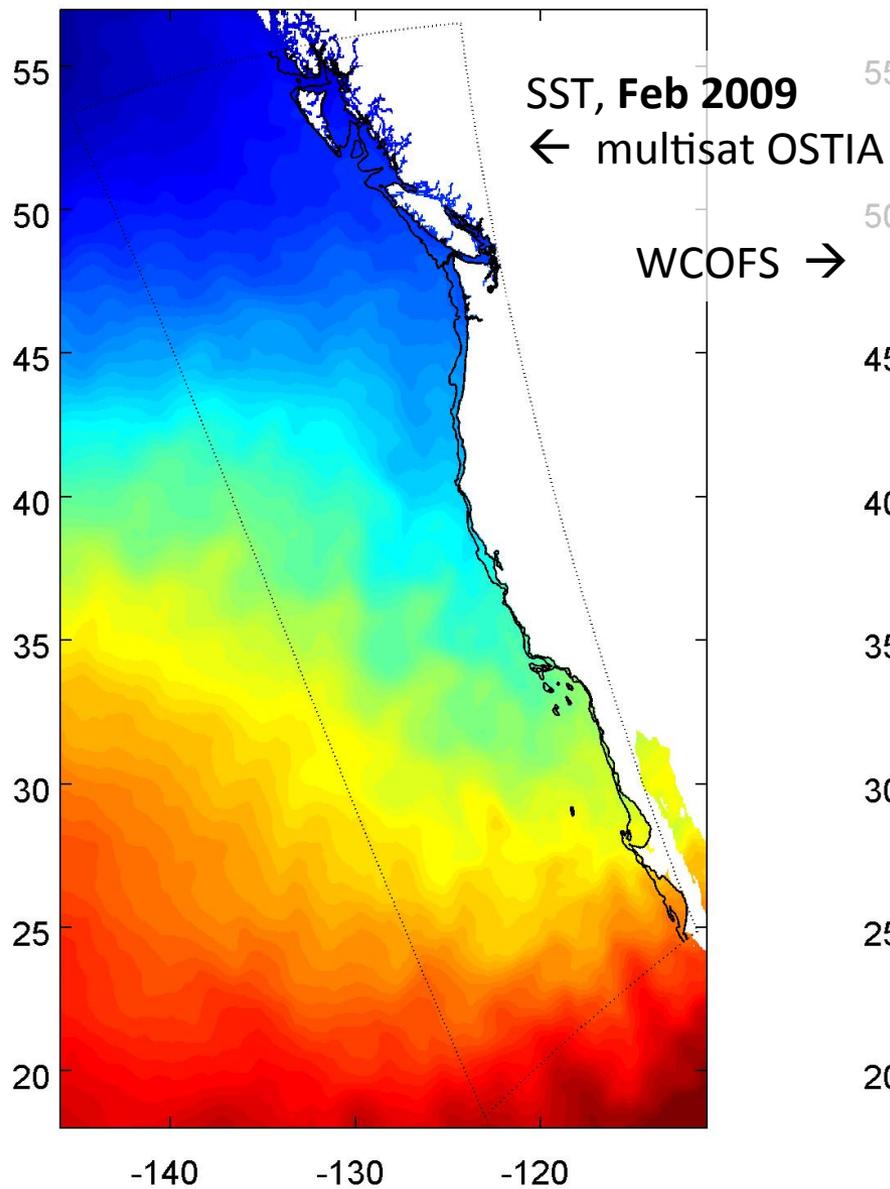
- Approx. 2-km horizontal resolution
- Atm. forcing: NOAA NAM (grid 218)
- Boundary conditions: Navy Global HYCOM (w/ data assimilation)

Products:

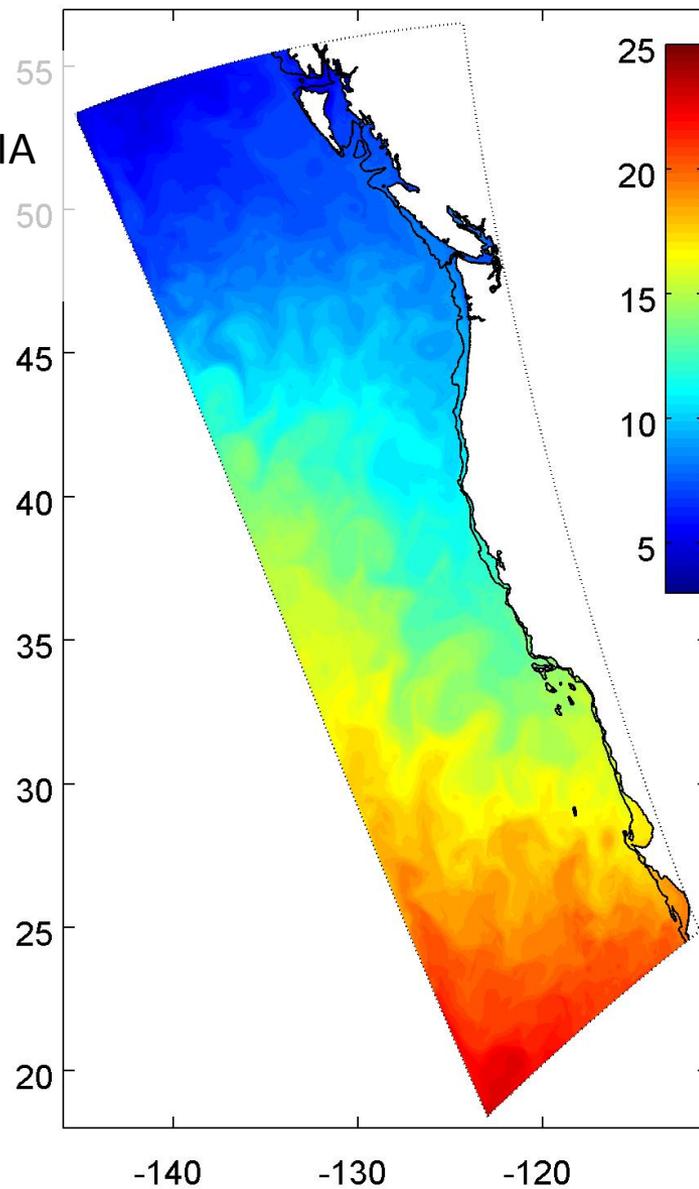
- Long run without assimilation (testing, model climatology)
- Real-time forecasts (3-7 days), w/ data assimilation (SSH, SST, in-situ obs.)



OSTIA 01-Feb-2009 ... 01-Mar-2009

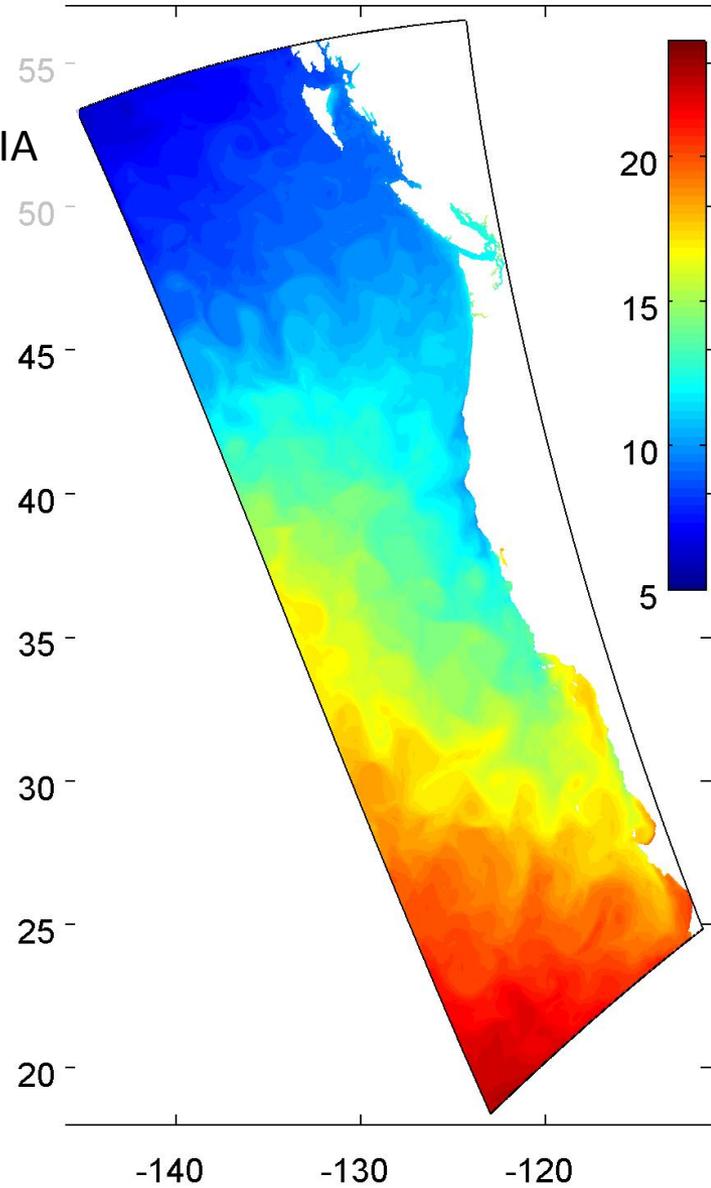
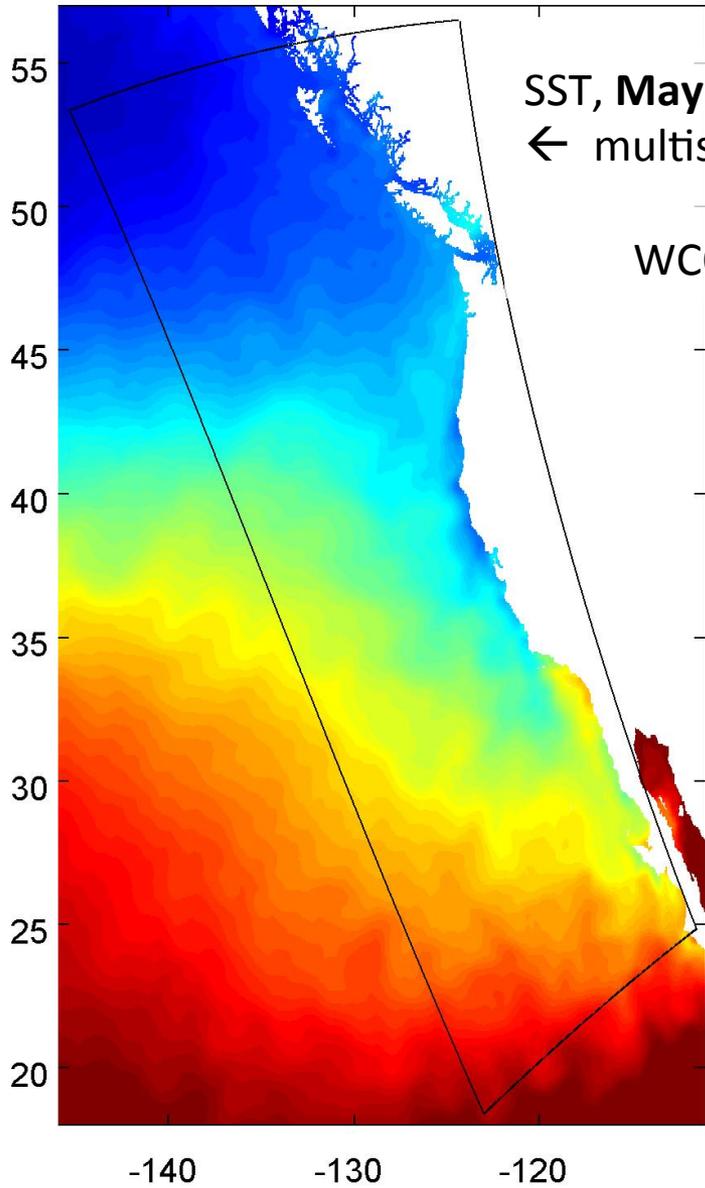


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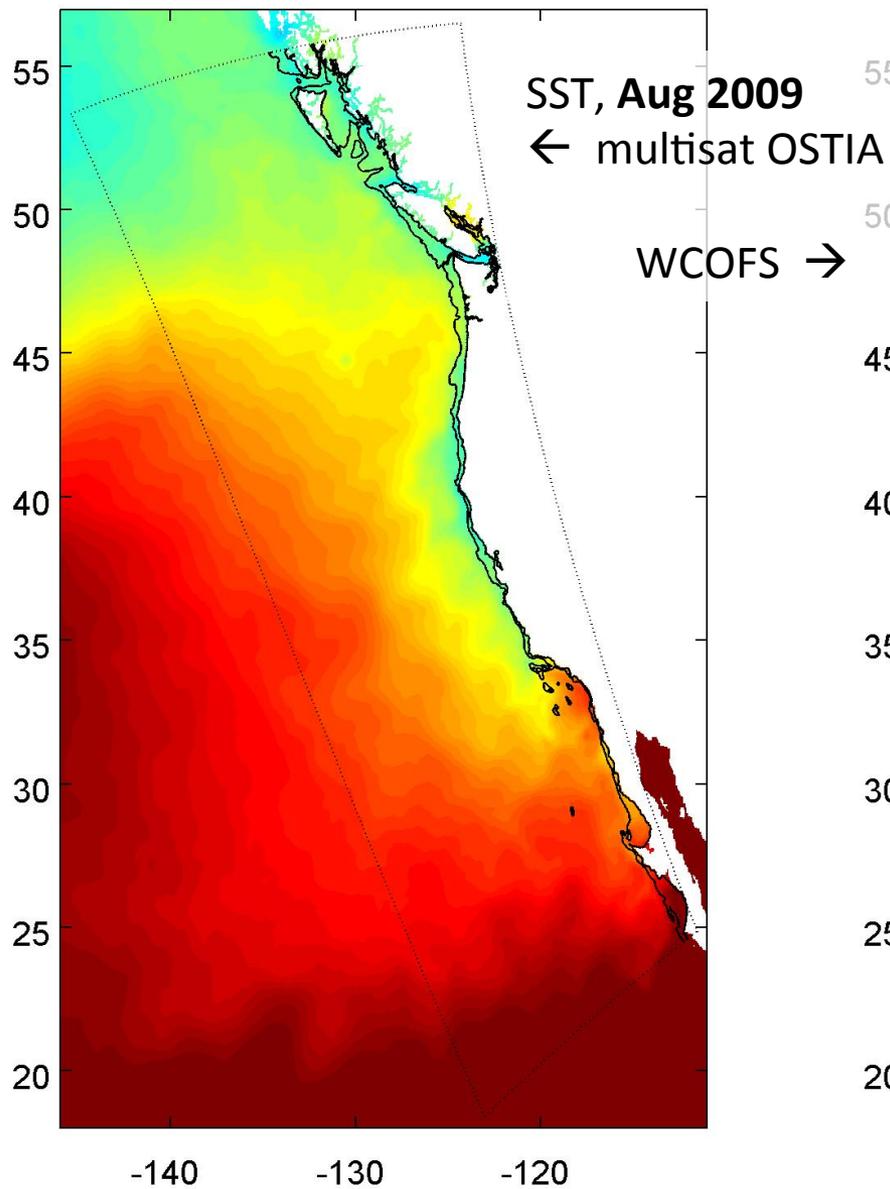
OSTIA 01-May-2009 ... 01-Jun-2009

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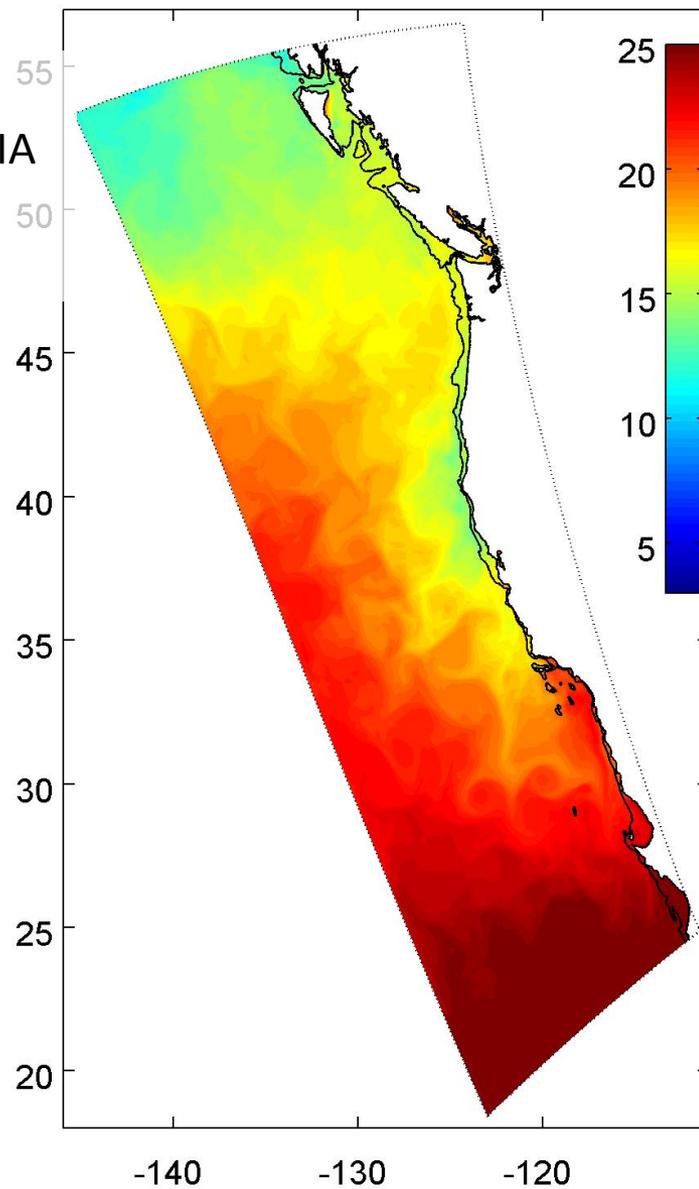


notes: (1) upwelling off OR and Northern CA, (2) warming in S. CA, just along the coast

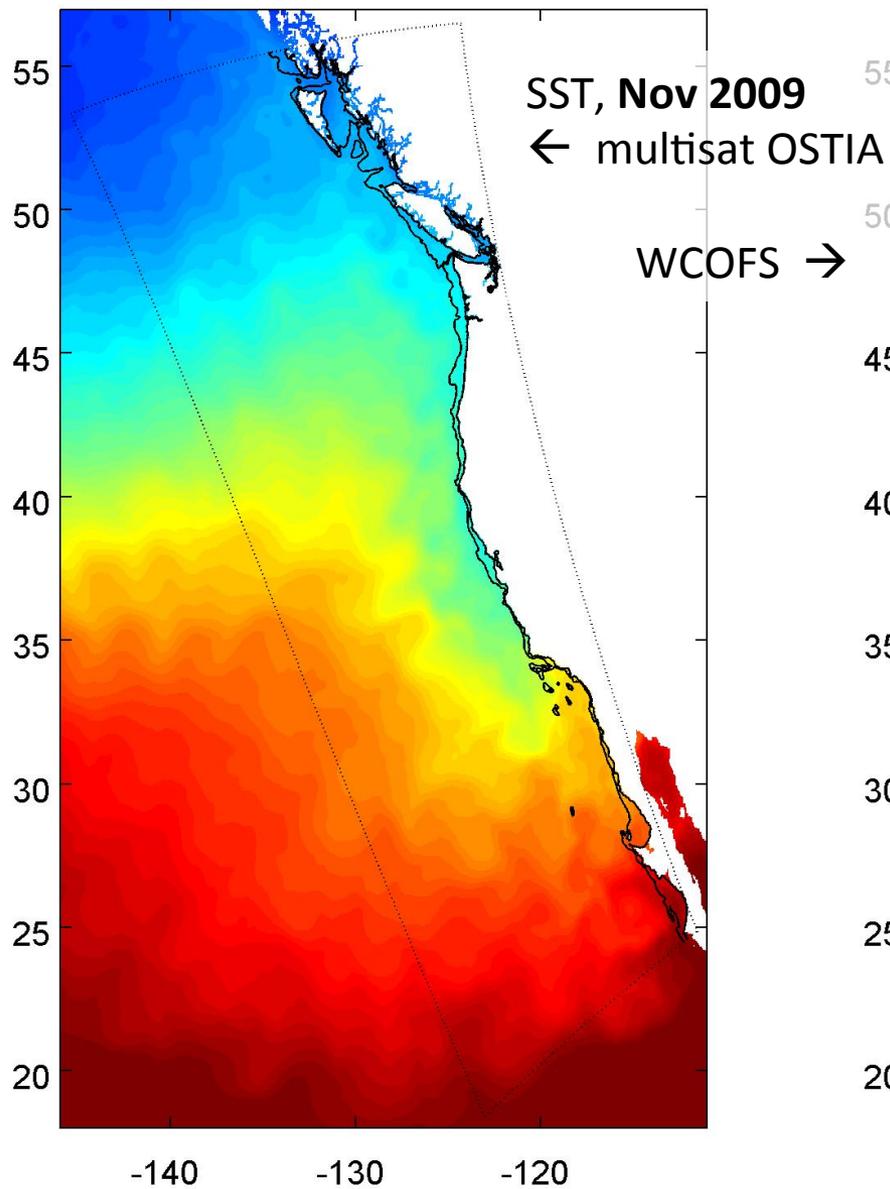
OSTIA 01-Aug-2009 ... 01-Sep-2009



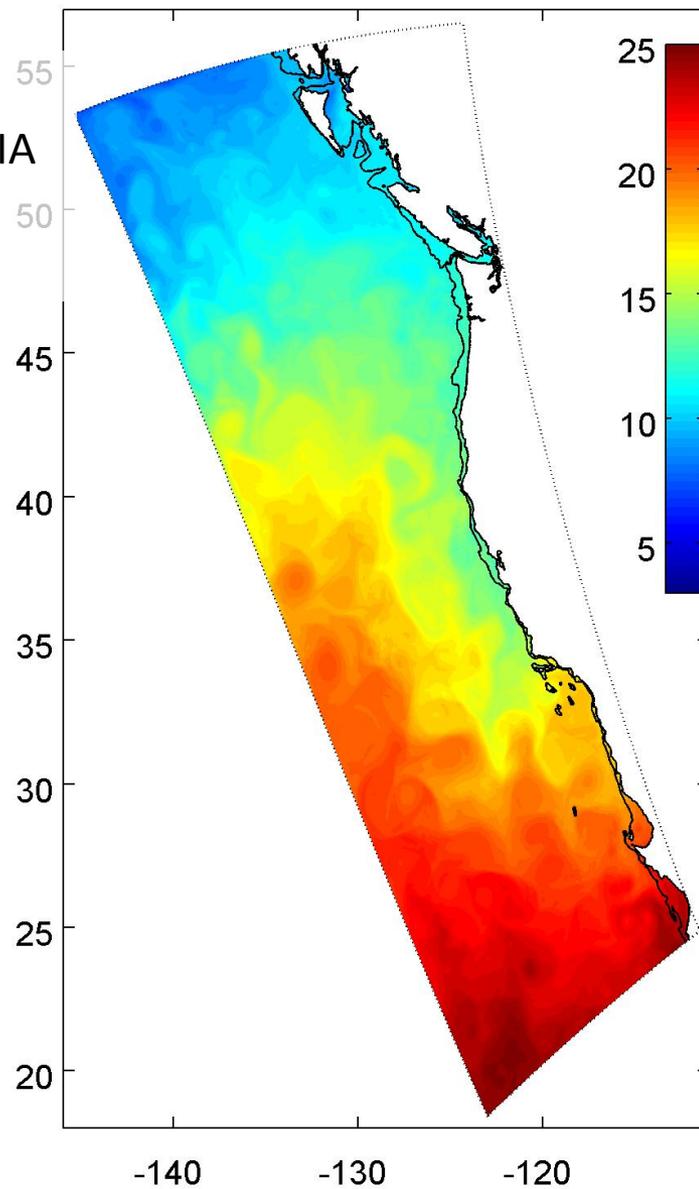
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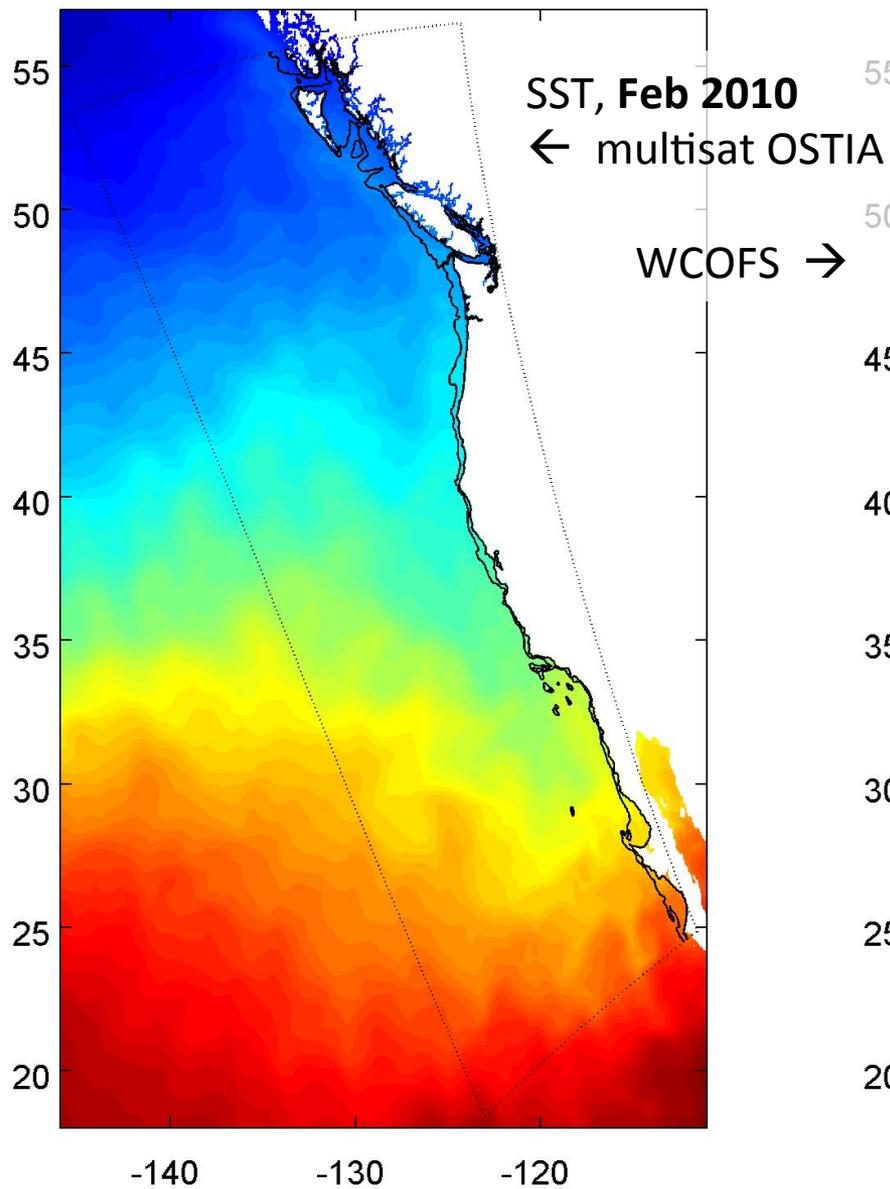
OSTIA 01-Nov-2009 ... 01-Dec-2009



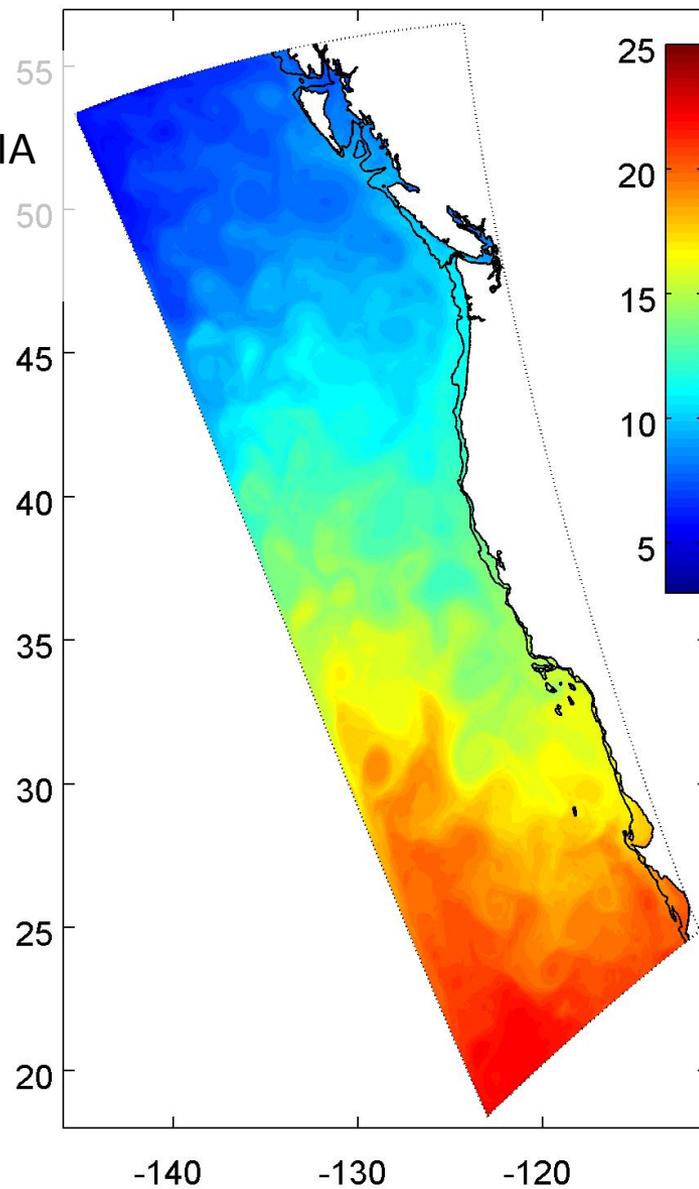
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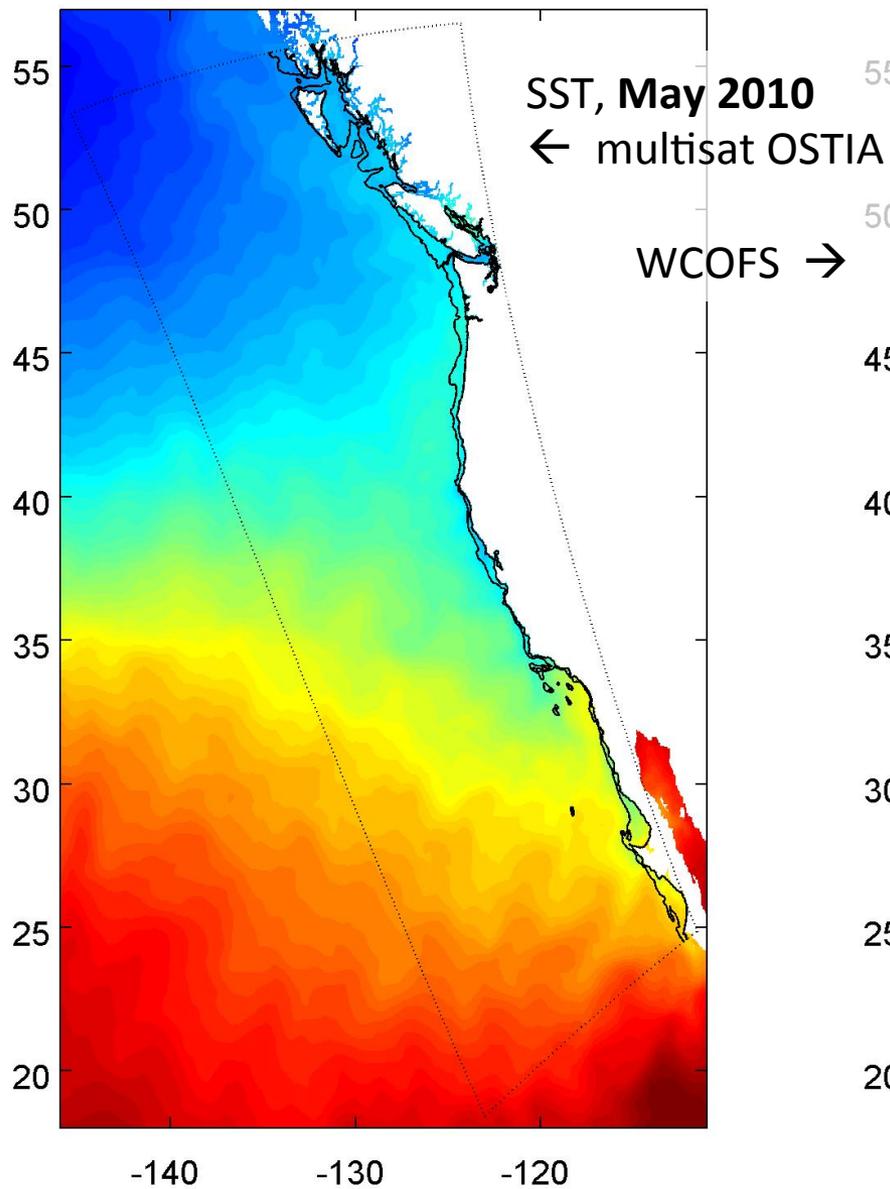
OSTIA 01-Feb-2010 ... 01-Mar-2010



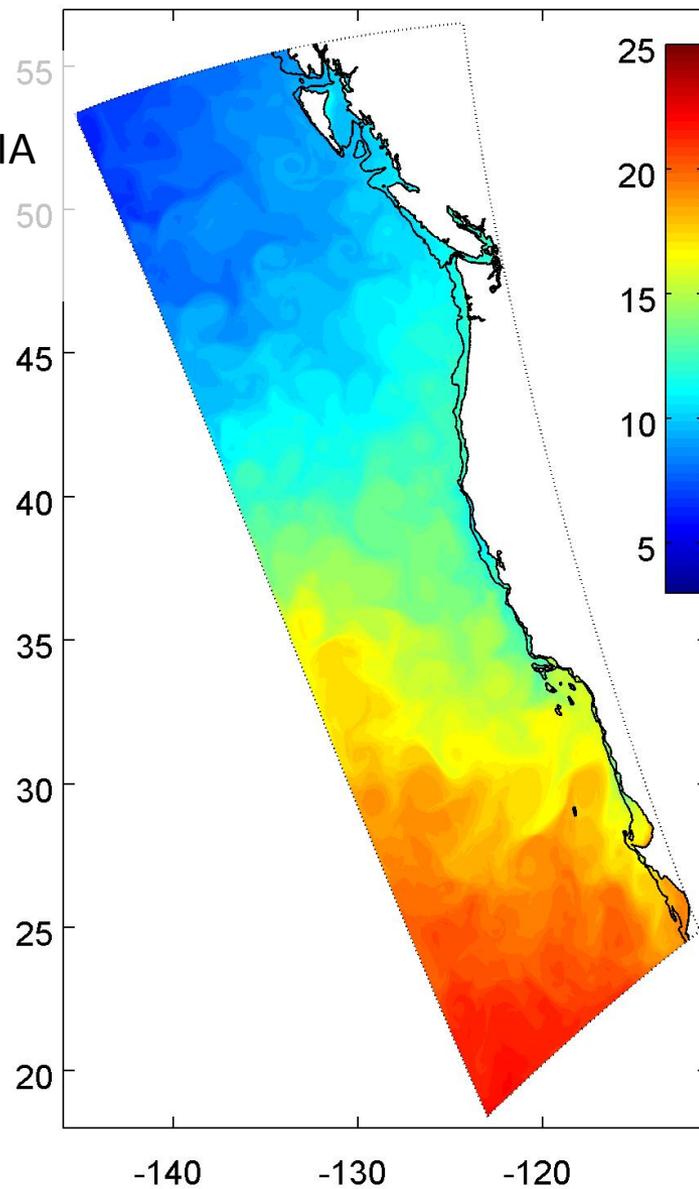
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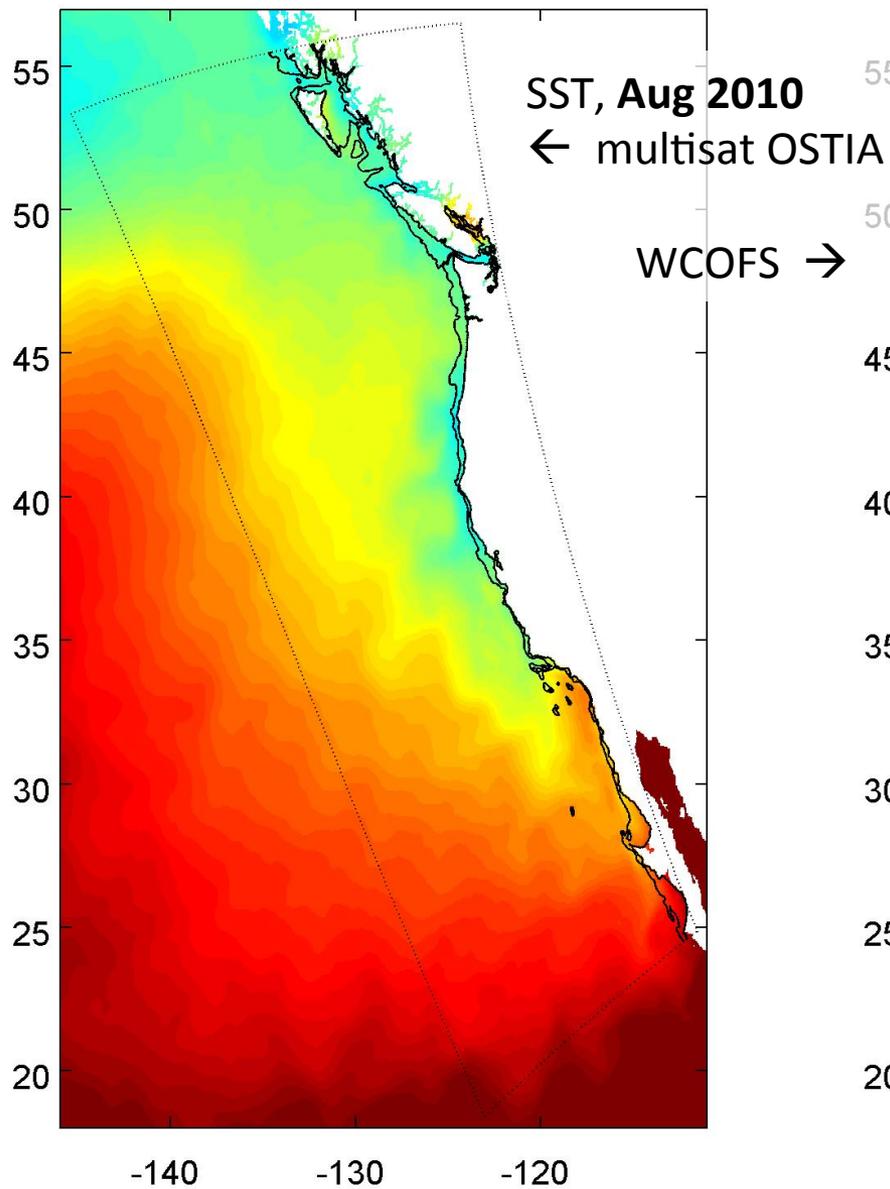
OSTIA 01-May-2010 ... 01-Jun-2010



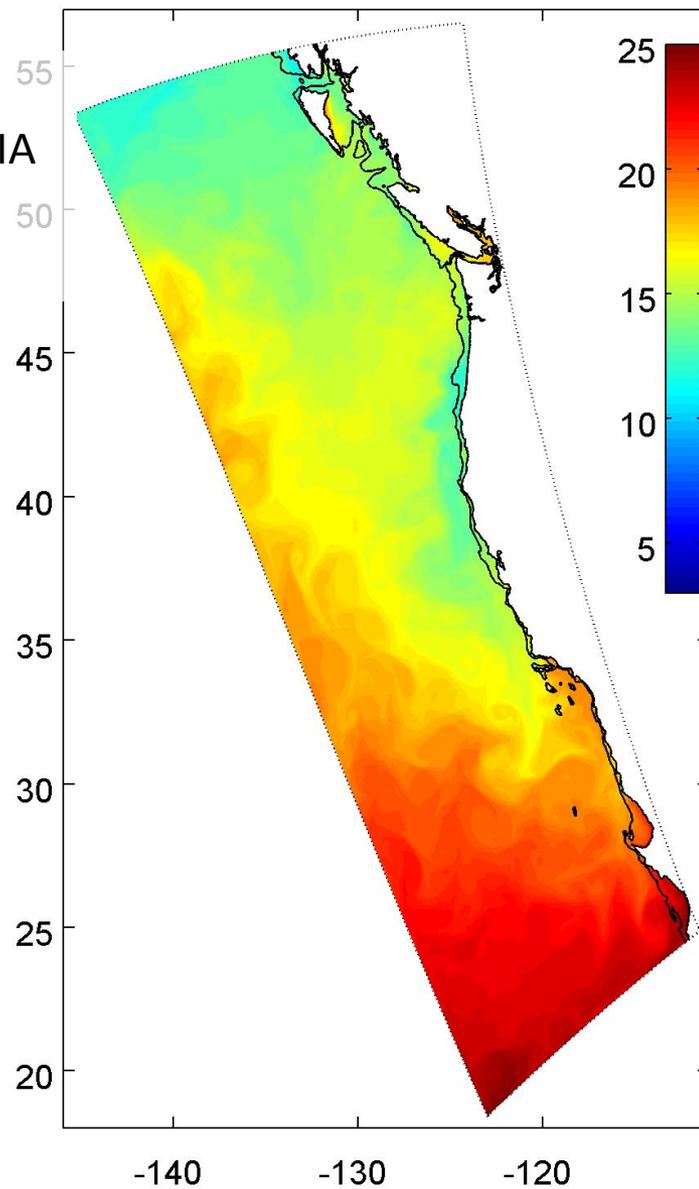
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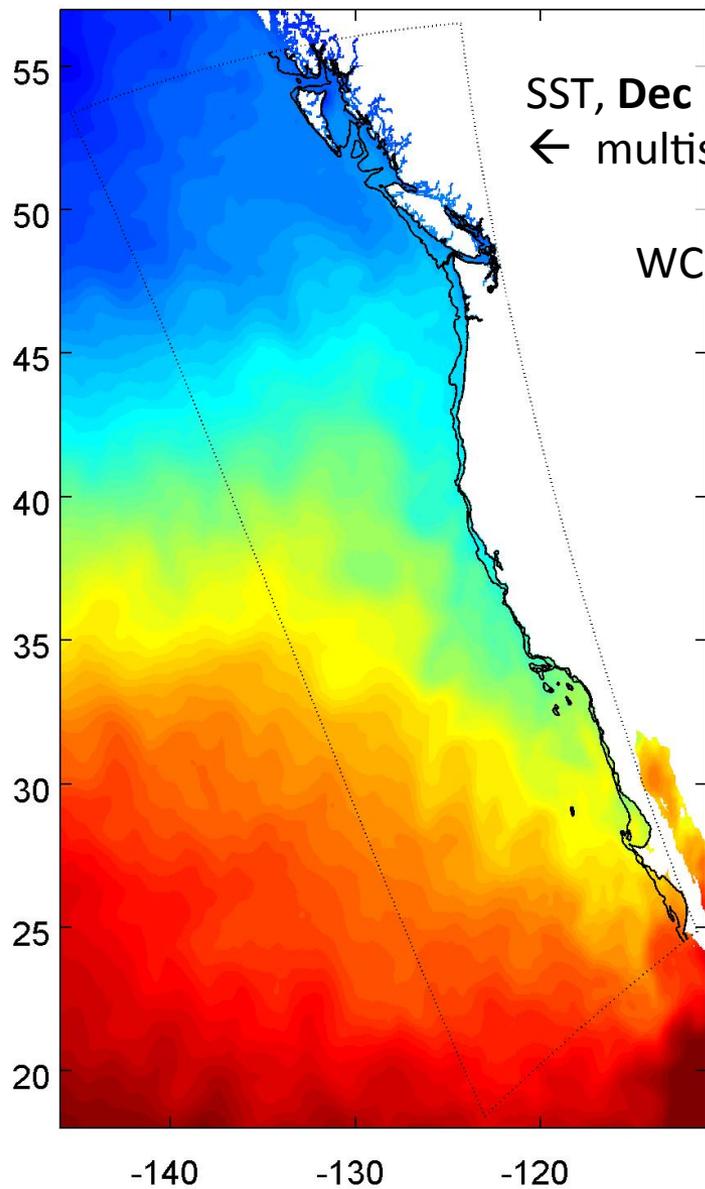
OSTIA 01-Aug-2010 ... 01-Sep-2010



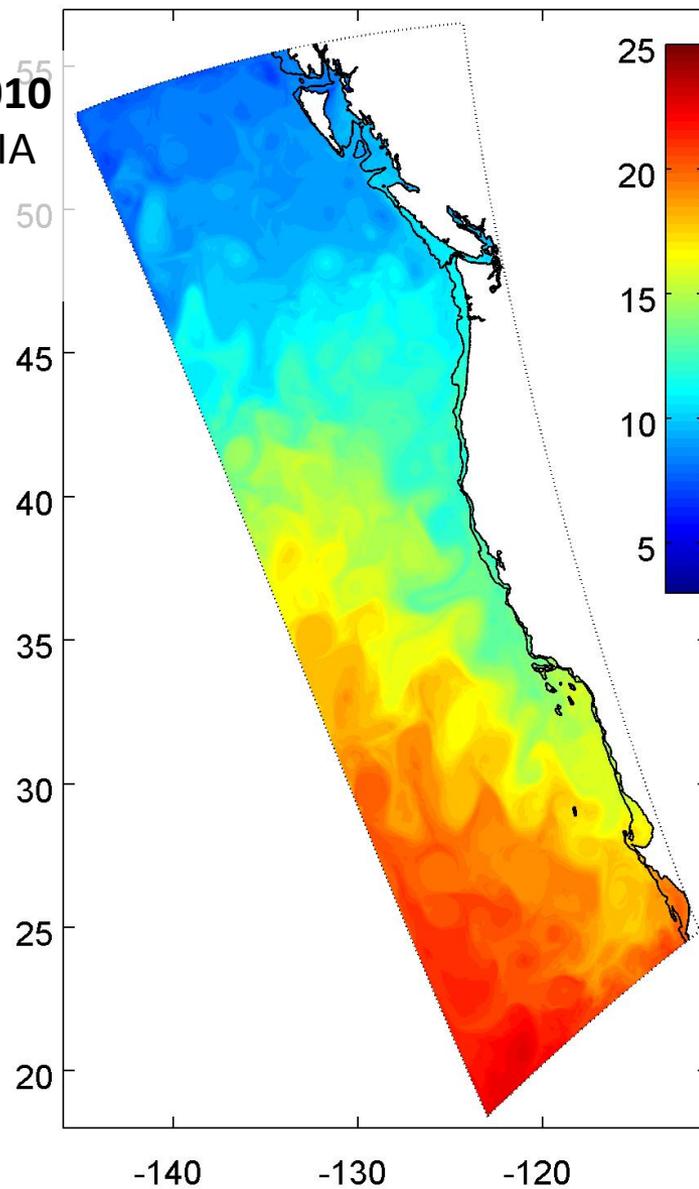
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OSTIA 01-Dec-2010 ... 17-Dec-2010



ROMS ../Exp03/Sample/Surf/



Daily averaged SST (31 May 2009)

Multisat OSTIA SST product (5-km res.)

WCOFS (2-km res.)

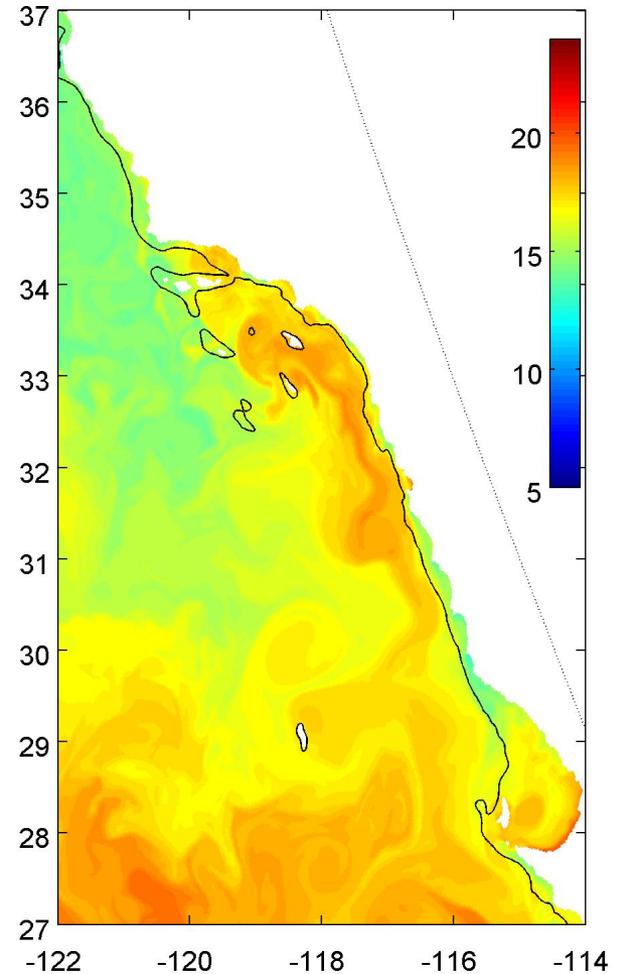
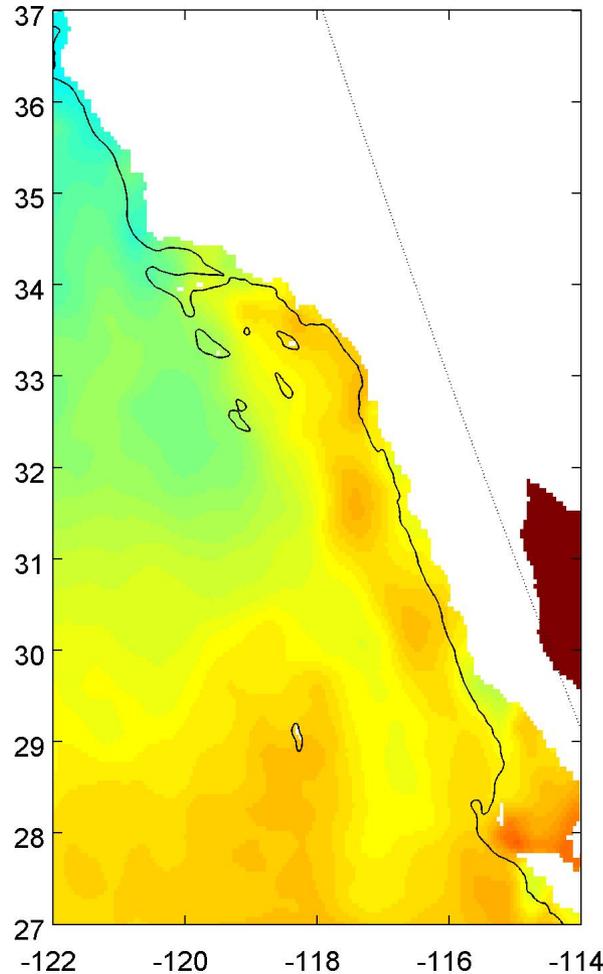
OSTIA 31-May-2009 ... 01-Jun-2009

ROMS ../Exp03/Sample/Surf/

note:
-narrow shelf
(black line is
H=200 m)

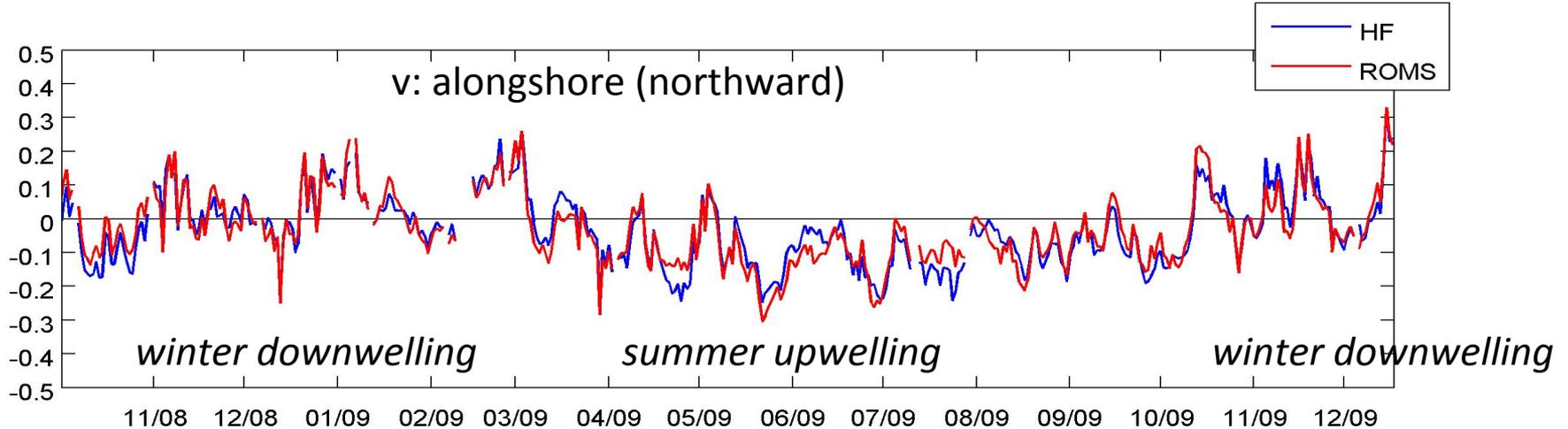
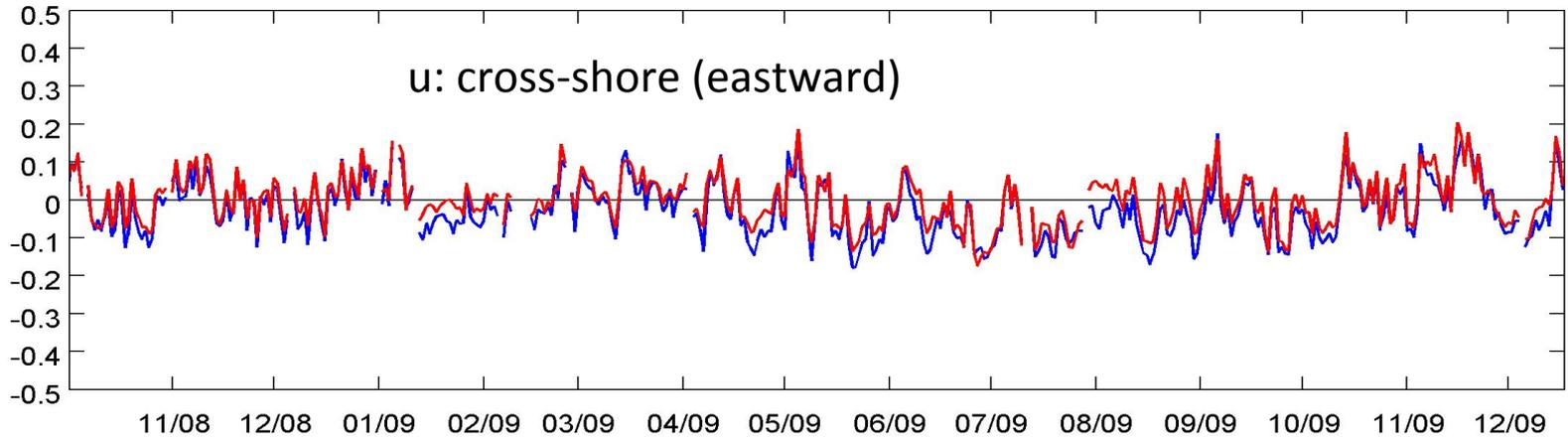
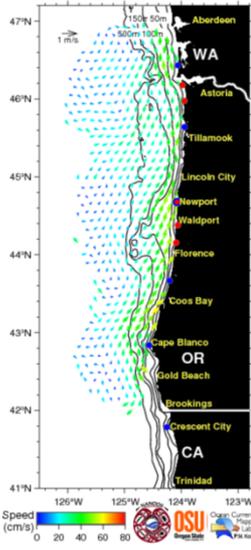
-a warm tongue
along the slope,
colder water
farther offshore

-colder water
over shelf
(Mexico),
local upwelling?



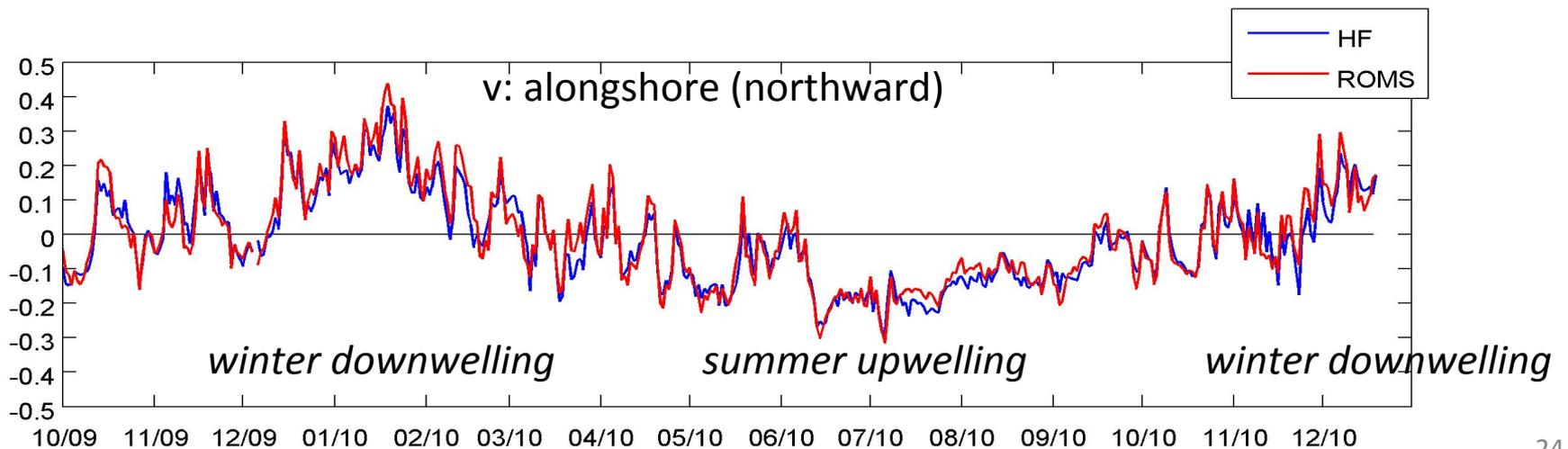
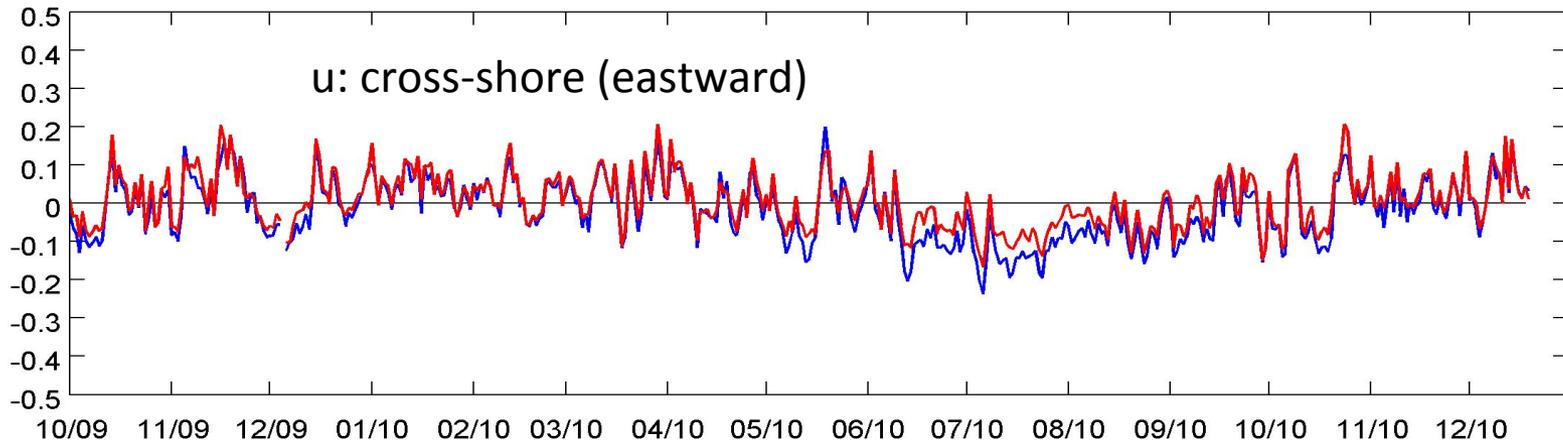
Area-averaged, daily-averaged surface current components off Oregon: **WCOFS** vs. **HF radar (Kosro)**

OCT 2008 – DEC 2009



Area-averaged, daily-averaged surface current components off Oregon: **WCOFS** vs. **HF radar (Kosro)**

OCT 2009 – DEC 2010

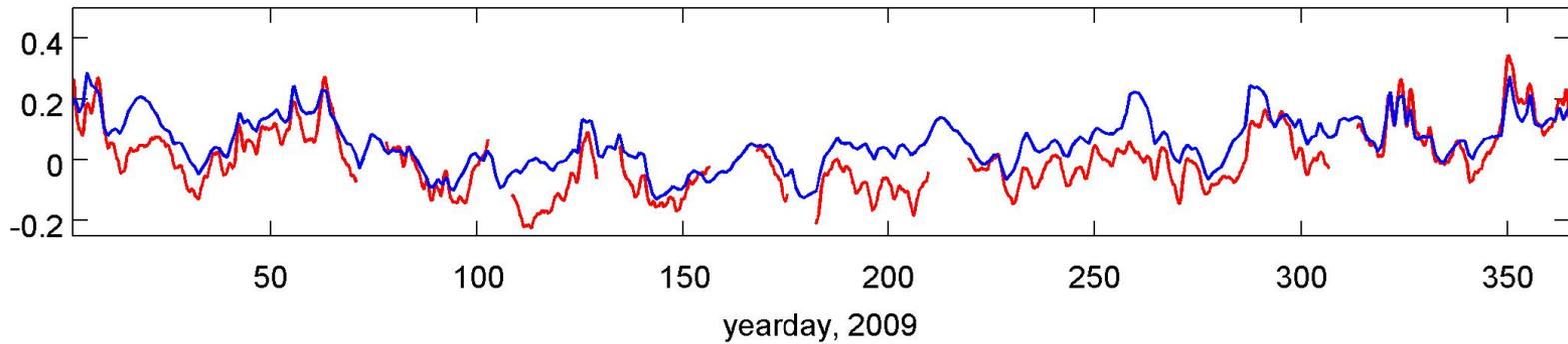


ROMS SSH vs. coastal tide gauge (44.65N, South Beach, OR)

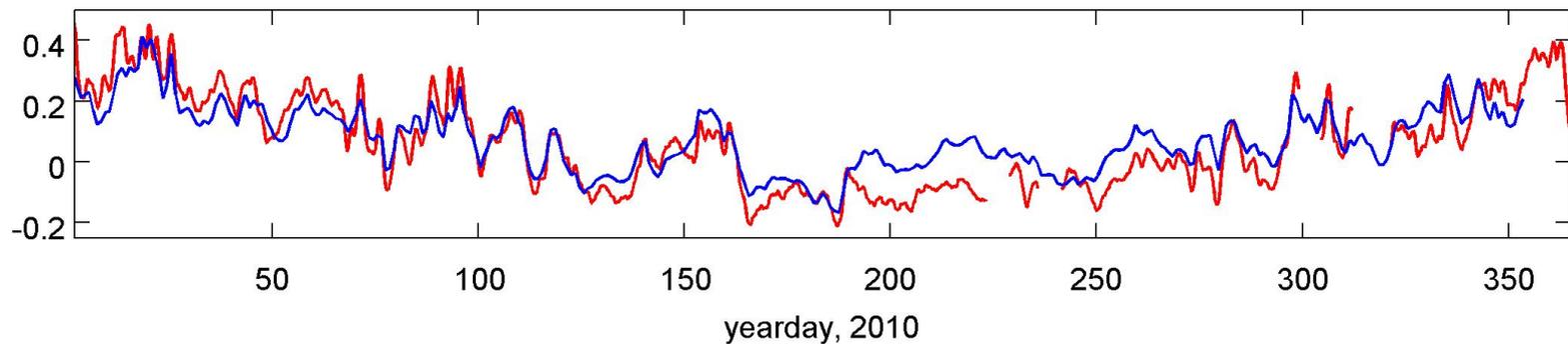
TG: low-pass filtered (40-hr half ampl.), inverted barometer correction using NAM P_{AIR}

ROMS: daily-ave

Daily ROMS (blue), lp TG w/ b/t pressure corr. (red)



Daily ROMS (blue), lp TG w/ b/t pressure corr. (red)



SUMMARY:

- Bio-chemical model intercomparison and optimization: improved parameters, guiding choice for the WCOFS bio-chemical model component
- Data assimilation intercomparisons: exploring synergies between methods, testing impact of different data on the ocean estimates
- Transition to operations: WCOFS
(successful initial runs, preparation for data assimilation)
(tests of WCOFS+NEMURO are in COMT yr. 3-5 plans)